

**ELECTRONIC DEVICE FOR A LITHOGRAPHY MASK CONTAINER,  
SEMICONDUCTOR MANUFACTURING SYSTEM, AND METHOD**

Related Application

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The present application is related to the commonly assigned United States application "Electronic device for a wafer container, wafer manufacturing system, and method" by Alain Charles et. al., identified by attorney  
10 docket number SC0098WD.

Field of the Invention

15 The present invention relates to integrated circuit fabrication and, more particularly, to a method and apparatus for handling lithography mask containers.

Background of the Invention

20 Integrated circuits are manufactured from semiconductor wafers in semiconductor factories ("wafer fabs"). The wafers are processed in a variety of stations, among them lithography stations ("exposure tools"). In the lithography station, the wafer is patterned by exposing  
25 it to electromagnetic radiation (e.g., ultra-violet light) going through a mask. The masks are sometimes referred to as lithographic reticle; an example is illustrated in United States Patent 5,849,440. The masks optionally have pellicles to keep away particles.

30 Between lithography stations as well as between stations and storage facilities, the masks are carried in mask containers (also known as "reticle holders"). Usually, the containers are made from plastic.

Due to their extraordinary precision and complexity, the masks are very expensive. It is therefore of paramount importance to handle the mask and the containers with extreme care. The diligence of a human operator is relied on, for example, when masks and containers are identified with handwritten labels. Unfortunately, people are relatively slow, quickly fatigued by repetitive tasks, and handling errors are potentially catastrophic.

10 Mask identification such as, for example, a tracking number, a type classification of the mask, lithography tool classification, is provided on the mask itself for visual inspection. However, inspecting a mask requires the operator to remove the mask from the container. For  
15 reading identification in machine-readable form (e.g., barcode, OCR), it may also be required to put the mask into a lithography tool. Besides the time needed by the operator or by the tool for identifying, mask inspection might (i) cause the generation of particles, (ii) damage  
20 the mask, or (iii) mix up the order of multiple masks in a single container.

There is an ongoing need to provide an improved mask container which mitigates some or all of these disadvantages and limitations of the prior art.

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Brief Description of the Drawings

FIG. 1 is a simplified block diagram of a semiconductor wafer manufacturing system with a first station, a  
30 second station, a mask container and an electronic device according to the present invention, wherein the device is associated with the mask container;  
FIG. 2 is a simplified block diagram of the electronic device of FIG. 1 with more detail;

FIG. 3 is a simplified block diagram of the system of FIG. 1 with more equipment; and

FIG. 4 is a simplified flow chart diagram of a system operation that comprises a method to operate the electronic device according to the present invention.

## Detailed Description of the Invention

- 10 The present invention provides an improvement to the lithography mask carrying container by providing an electronic device that is attached to the container. By storing and processing data, the device helps to increase efficiency in the semiconductor wafer factory.

15 FIG. 1 is a simplified block diagram of semiconductor wafer manufacturing system 100 ("factory", "wafer fab") with first station 110, second station 120, mask container 200, and electronic device 205 ("device")

20 according to the present invention. Device 205 is associated with mask container 200 and comprises: receiver unit 210 to receive first data 111 (arrow), memory unit 220 to temporarily store first data 111, processor unit 230 to process first data 111 and to

25 provide second data 122 (arrow), and transmitter unit 240 to transmit second data 122.

Mask container 200 (hereinafter "container") is any suitable enclosure that protects lithography mask 201 from contamination (e.g., by particles). Usually, 30 container 200 has slots 207, each for holding a single mask 201. Container 200 carries at least one mask 201; however, up to N masks in a single container can be carried. For example, a mask container designed for 300 millimeter wafer factory can carry up to preferably

N = 6 masks. However, this value can be higher. For convenience, the following explanation uses the term "mask" in singular with the intention that "mask" stands for any number between 0 and N of masks. Container 200  
5 can also be empty, for example, for container 200 that is being cleaned.

Mask container 200 carries lithography mask 201 between first station 110 and second station 120. Station 110 uses mask 201 (or container 200) in a first  
10 process (cf. step 310 in FIG. 4); at a later time-point, station 120 uses mask 201 in a second process (cf. 320 in FIG. 4).

Preferably, first data 111 is indicative on how station 120 has used mask 201 in the first process, and  
15 second data 122 is indicative on how station 120 uses mask 201 in the second process. Preferably, transmitter unit 240 transmits second data 122 to station 120 before station 120 uses mask 201 in the second process.

Preferably, processor unit 230 processes first data  
20 111 by combining first data 111 with instruction 131. Preferably, instruction 131 is a set of commands of computer executable program code. Preferably, instruction 131 is also indicative on how mask 201 is used in the second process. Receiver unit 210 receives  
25 instruction 131, for example, from a host computer (cf. FIG. 3). It is convenient that receiver unit 210 receives first data 111 at a first time point and receives instruction 131 at a second time point that comes later. Protocols that ensure reception and  
30 transmission to receiver unit 210 and from transmitter unit 240 are well known in the art. Optionally, processor unit 230 receives first data 111 from sensor 270 located within mask container 200.

The term "using a mask in a process" (and its language variations) is intended to comprise at least one of the following actions:

- inserting mask 201 into container 200;
- 5   • removing mask 201 from container 200;
- in combination, inserting and removing multiple masks 201/202 (cf. FIG. 3);
- writing data to mask 201 (e.g., by adding a barcode label);
- 10   • reading data from mask 201 (e.g., reading the barcode label);
- exposing a semiconductor wafer (not illustrated) or any other work-product by sending electromagnetic radiation through mask 201;
- 15   • storing mask 201;
- transporting mask 201 from one location to another location within the wafer factory (cf. FIG. 3);
- manufacturing mask 210;
- maintaining mask 210 (e.g., cleaning);
- 20   • modifying mask 201 by changing its exposure properties (e.g., through aging);
- damaging mask 201, disposing of mask 201, recycling mask 201, or any other action that removes mask 201 from the factory;
- 25   • testing and measuring the properties of mask 201, either directly (e.g., evaluating an exposure picture), or indirectly, (e.g., evaluating a wafer exposed to radiation by the mask);
- assigning an identifier for mask 201;
- 30   • assigning an identifier for a plurality of masks 201 (e.g., type classification); and

- transferring information that relates to mask 201 from a first electronic device in a first container to a further electronic device in a further container.

This action catalogue will be referred to later in  
5 connection with a method.

For example, and without the intention to be limiting, station 110/120 can be the following: a mask sorter for inserting the mask into the container, removing the mask from the container, inserting and removing multiple masks  
10 to and from the container; a lithography exposure tool for exposing a semiconductor wafer (not illustrated) or any other work-product by sending electromagnetic radiation through the mask (the main purpose of the mask); a transport tool (e.g., automated vehicle, robot),  
15 for transporting the mask from one location in the factor to another location in the factor, or for storing the mask, for writing data to the mask or reading data from the mask; a manufacturing tool for manufacturing the mask (preferably, outside the factory), for assigning a single  
20 identifier for a single mask or a single identifier to a plurality of masks; a metrology tool for testing and measuring the properties of the mask; a cleaning tool for removing contamination from the mask; or any other equipment inside or outside the factory that serves one  
25 or more actions referred to in the catalogue.

Some actions are unwanted and can occur by chance in any station, such as damaging the mask by accident.

Application examples are given later. Having used the term "mask" in connection with the above mentioned  
30 actions is convenient; however, persons of skill in the art are able, based on the disclosure herein, to practice the present invention also for actions with mask containers 200, independently whether the container carries a mask or not.

FIG. 2 is a simplified block diagram of electronic device 205 of FIG. 1 with more detail. Electronic device 205 is shown with receiver unit 210, memory unit 220, processor unit 230, transmitter unit 240, as well as with bus 250 coupling them. Preferably, processor unit 230 and memory unit 220 are implemented on a single monolithic chip ("embedded microprocessor", dashed frame 208).

Preferably, receiver unit 210 and transmitter unit 240 are combined to transceiver unit 260. Conveniently, transceiver unit 260 is a wireless transceiver operating as radio frequency transceiver (cf. antenna 261), or an infra-red transceiver (cf. optical interface 262 with symbols for a light emitting diode (LED) and for a photo diode). Persons of skill in the art are able to use other wireless transceivers without the need of further explanation herein. For example, a transceiver can comprise inductive coils. In case of a wire-bound transceiver, a direct electrical contact to the environment of device 205 is established (not illustrated).

Preferably, memory unit 220 is a non-volatile memory, such as an EEPROM or an SRAM. Volatile memories can also be used (e.g., DRAM). Conveniently, instruction 131 stored in memory unit 220 optionally comprises also information about further processes (additionally to process 320).

Power supply 280 for units 210/240, 220, 230 is implemented by a long lasting small battery, by a photovoltaic element, by a thermal converter, by an inductive power converter that relies on externally applied electromagnetic energy or by any other suitable power supply means.

Preferably, device 205 remains attached to container 200 permanently; i.e., also when container 200 is cleaned. A convenient attaching means is adhesive 209. Preferably, device 205 is located at the same location 5 for all containers 200 in factory 100. Attaching device 209 outside the container, for example, outside its plastic enclosure is convenient.

Further modifications are possible. For example, container 200 can have a barcode tag; an operator 10 interface (e.g., display, buzzer, keys) can also be provided with device 205.

FIG. 3 is a simplified block diagram of factory 100 of FIG. 1 with more equipment: stations 110/120 (cf. 15 FIG. 1), third station 130, container transportation means 101, factory transmitter 155, station transmitters 115, 125, 135 (at stations 110, 120, 130, respectively), 20 105 host and factory bus 150 ("backbone"). The combination of container 200 with device 205 is shown in station 110. Depending on the second data, combination 200/205 is moved to station 120 or, optionally, moved to station 130. FIG. 3 also shows further container 200' and further device 205'.

In the example of FIG. 3, container 205 carries mask 25 201 and mask 202 (cf. above maximum N masks). There are applications (e.g., rearranging masks) where second data 122 (cf. FIG. 1) also determines the quality and quantity of third process 330 in a third station 130 using mask 202.

30 Factory transmitter 155 is a long range transmitter that exchanges data (e.g., data 111, 122, instruction 131, cf. FIG. 1) with device 205 independently from its location. Preferably, transmitter 155 simultaneously communicates with further devices. As mentioned,

protocols are well known: the operation in time frames ("time slots") is one option.

In comparison to the factory transmitters, station transmitters 115, 125, 135 have a range that is, preferably, reduced to local communication between device 201 and stations 110, 120, 130, respectively.

Communication between device and station occurs when both are proximate, with an actual distance varying based on what kind of transceiver 260 is used.

In factory 100 with a plurality of container/device combinations 200/205, data is exchanged between devices as well as between stations and devices. In other words, transceiver 260 of electronic device 205 communicates with further electronic device 205' at further container 200' and with further stations. Where needed, communication can be routed at least partly via factory bus 250, for example, in coordination by host 105.

FIG. 4 is a simplified flow chart diagram of a system operation 350 that comprises method 300 to operate electronic device 205 according to the present invention. Operation method 350 comprises: using a lithography mask (cf. mask 201) in first process 310, using the mask in second process 320, and method 300 to operate device 205 (dashed frame). Using the mask in third process 330 is optional. Method 300 comprises the steps receiving (sending) 302, processing 304 and transmitting 306.

Method 300 is performed after first station 110 has used the mask in first process 310 and, preferably, before second station 120 uses the mask in second process 320.

In receiving step 302, device 205 receives first data 111, preferably, from first station 120 or from host

computer 105 (cf. FIG. 3). First data 111 indicates quality and quantity of first process 310.

Based on first data 111, in processing step 304, device 205 processes first data 111 in step 304, preferably, by combining first data 111 with instruction 131 (cf. FIG. 1). By indicating the expected quality and quantity of second process 320, instruction 131 indicates how the mask is used in second process 320. As mentioned above, processing 304 is performed to provide second data 122 that determines final quality and quantity of second process 320. In transmitting step 306, device 205 transmits second data 122, preferably, to second station 120 or to host computer 105.

Optionally, in processing step 304, device 205 provides third data for an alternative third process 330 (dashed line) and in transmitting step 306, device 205 transmits the third data to third station 130. Conveniently, the third data is provided to control third process 330 using further mask 202 (cf. FIG. 3).

Returning to explain method 350 to operate wafer manufacturing system 100 (that uses lithography mask container 200 having electronic device 205 attached thereto), method 350 is presented as follows:

Step 310, first station 110 applies first process 310 using mask 201; step 302, first station 110 sends first data 111 to electronic device 205 (data 111 indicates quality and quantity of process 310), electronic device 205 receives first data 111; step 304, electronic device 205, based on first data 111, qualifies instruction 131 (processing to indicate expected quality and quantity of process 320) to provide second data 122; step 306, electronic device 205 transmits second data 122 to second station 120 (or to the host); step 320, second station 120 applies second process 320 using mask 201.

In short, operating a manufacturing system for semiconductor wafers (employing a plurality of lithography masks, carried in plurality of mask containers) comprises the following steps: collectively  
5 for steps 302/304/306, (a) exchanging data 111 relating to predetermined process 310/320 between electronic device 205 (attached to container 200) and host computer system 105; and (b) using lithography 201 mask in station 110/120 in predetermined process 310/320, wherein using  
10 is an action described in the catalogue above.

The following column-like overviews explain representative applications for the present invention. For all cases, similar left columns indicate station 110 with process 310 using mask 201, first data 111, optional instruction 131, second data 122, and station 120 with process 320; and if applicable, third station 130 and third process 330 (cf. FIG. 4). The right columns give examples; reference numbers for device 200, mask 201, etc. are left out for simplicity. The applications are intended to be non-limiting examples; those of skill in the art will find further applications without departing from the scope of the present invention. The phrase "for example" is therefore incorporated by reference into each text line on the right side.

Example 1: Sorting masks

station 110 mask sorter  
process 310 setting up an arrangement of masks by selectively inserting or removing masks  
5 from the container  
data 111 table with mask and slot identification  
data 122 lithography station targeted for using each the masks  
process 320 lithography

10 This approach allows the reduction of overhead in the host. Optionally, station 120 can authenticate incoming masks to avoid using the wrong one. Tracking each individual mask as it goes through the factory becomes possible.

Example 2: Shifting masks between containers

station 110 mask sorter  
process 310 shifting masks from a first container to a second container  
20 data 111 identification for each mask stored in the electronic device of the first container  
data 122 identification for each mask to be stored in the electronic device of the second container, also assigning an identifier to  
25 the second container  
process 320 transferring data between the electronic devices, preferably, via the host computer or directly from device to device

Example 3: Recording restrictions, inspection results  
station 110 any station, mask manufacturing equipment,  
lithography tool

process 310 manufacturing, exposing wafers by  
5 lithography

data 111 restrictions for use, specific to  
wavelengths or caused by defects on the  
mask

data 122 optionally, identical to data 111, also  
10 processed to fit to the lithography  
station that uses the mask next

process 320 exposing wafers by lithography wherein the  
restrictions are considered

15 Example 4: Recording mask lifetime

station 110 any station that by using the mask changes  
the properties of the mask, especially,  
fast aging for lithography that uses  
wavelengths less than 200 nm

20 process 310 exposing wafers by lithography

data 111 the number of exposure steps for that the  
mask has been used

inst. 131 the command to compare this number to a  
predetermined maximum number

25 data 122 indication whether the mask is acceptable  
for use or not

process 320 exposing wafers by using acceptable mask,  
or

process 330 replacing unacceptable mask

Example 5: Monitoring transportation system

station 110 any station that transports the container,  
or comes into contact with the masks, such  
as loadports for lithography tools  
5 data 111 problems encountered with certain loadport  
data 122 identification of alternative loadport  
process 320 using alternative loadport

Optionally, some or all of station transmitters 115, 125,  
10 135 (cf. FIG. 3) can be implemented by portable devices  
with displays. This allows the factory operator to  
access electronic device 205 at substantially any  
location.

15 While the invention has been described in terms of  
particular structures, steps, devices and materials,  
those of skill in the art will understand based on the  
description herein that it is not limited merely to such  
examples and that the full scope of the invention is  
20 properly determined by the claims that follow.